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# Hub dependence in constrained economies

## The case of North Korea

César Ducruet

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### Abstract

While the geographical and economic factors concerning the development of hub ports are widely described by a variety of scholars and professionals, there is no recognized methodology measuring the hub dependence of a given port, region, or country. Based on a 20-years database of vessel movements, this paper proposes a methodology measuring hub dependence. North Korea offers a good case of a constrained economy facing dramatic internal and external pressures. Notably, the weight and geographical extent of its maritime connections are worth analysing because of its contrasted evolution from Soviet influence, geopolitical isolation, and growing trade due to economic reforms and increased foreign investments. The main results of this study show the spatial shift from long-distance calls to feeder calls: global foreland contraction, regionalization within Northeast Asia, and traffic concentration upon closest hubs of which South Korean ports. We conclude that hub dependence is a combination of local constraints and trade growth. The political implications of this phenomenon are explored, and a spatial model of hub dependence is proposed.

*Keywords: DPRK, Hub, Maritime network, North Korea, Port, Spatial model*

## Introduction

The development of hub ports is by no means a recent phenomenon. Port concentration and selection, stemming from the strategies of main carriers, and technological changes in sea transport [1] [2] have resulted in traffic concentration among port systems worldwide [3]. This has led to considerable loss of traffic and related economic impacts for traditional trading ports. Measuring the degree of hub dependence is a major issue for several ports of the world, but there has been little efforts analysing the hub dependence of a given country, region, or port. Most studies describe unprecedented traffic growth at emerging hubs without assessing the degree to which existing trading ports are becoming hub dependent. Such a lack of studies is mainly caused by the absence of relevant datasets on inter-port traffics. Port authorities themselves ignore the detailed maritime origins and destinations of the ships, and freight forwarders do not release data on transport chains. Only estimations from the press give approximate figures of hub dependence such as the 80% of Indonesian traffics flows passing through Singapore and Malaysian ports [4]. Former quantitative approaches such as network analysis [5] [6] [7] and network connectivity [8] are difficult to apply systematically due to the volumes of data and the complex methodologies needed.

As a result, most studies dealing with hub dependence are qualitative case studies, as seen in Indonesia [9], South China [10], post-Apartheid South Africa [11], and post-Soviet countries [12] [13] [14]. All authors highlight the reduced hub dependence on neighbouring transit ports (i.e. Singapore, Hong Kong, and Rotterdam) by attracting more direct calls of global ocean carriers. Conversely, Japanese ports are increasingly hub dependent on the South Korean ports of Busan and Gwangyang [15].

In this paper, the Democratic People's Republic of Korea (DPRK, hereafter referred to as North Korea) provides a remarkable example of a constrained economy. The impact of this particular situation on port development and maritime trade is worth analysing. Although the

North Korean transport system is dominantly continental, due to the influence of the soviet development model and to preferential trade relations with China and Russia, the activity of the eight trading ports, because they support all other trade relations, is a good indicator of the position of North Korea in the world economy (see figure 1).

[Insert figure 1 about here]

The main purpose of the study is:

1. to propose a methodology for analysing the hub dependence of a given country;
2. to determine which factors give birth to hub dependence in the case of North Korea;
3. to contribute to the literature by proposing a three-stage model of hub dependence;
4. to discuss the implications of hub dependence for port and economic development.

This paper is organized as follows. The first section introduces data source, methodology, and selected indicators assessing hub dependence. The second section presents a brief description of the North Korean economy and analyses the data for the study. The third section details more the economical and political conditions underlying the hub dependence of North Korean ports and it introduces a three-stage model of hub dependence as a base for comparison. Finally, conclusive remarks are given about the implications of the research for policy making and maritime studies.

## **1. Measuring hub dependence**

### **1.1 Data sources**

Given the scarcity and poor quality of data on North Korean ports, recent studies have used independent sources [16]. Lloyd's Marine Intelligence Unit (LMIU) database is one

possible source to address inter-port issues. It covers approximately 80% of the world's merchant fleet and 70% of the world's trade volumes. The extraction of North Korea-related data from the original global database raises some important issues.

First, vessel movements are collected by Lloyd's based on the continuous and daily circulation of the insured ships, regardless of the specific sailing schedules of shipping companies. The domination of bulk traffics and tramping in North Korea lowers the disadvantage of ignoring this information. Thus, the advantage of Lloyd's database is that it harmonizes the great complexity of movements, schedules, and periods. However, ports of origin cannot be distinguished from ports of destination; thus, trading ports cannot be distinguished from transit ports. Because most ships are used for multiple routes, it is impossible to evaluate the share of North Korea in the total movements of every ship. Also, the passage of a ship in a port does not mean that any cargo has been loaded or unloaded at this port. Yet, we assume that connecting North Korean ports has some influence on the overall circulation pattern of those vessels.

Second, assessing hub dependence necessitates distinguishing direct from indirect relations between North Korean ports and other ports. We postulate that hub dependence should be measured at directly connected ports, although there is no clear evidence that feeder calls are always direct links. Direct relations form a first maritime ring (see figure 2) defined by previous and next ports of call; indirect relations form the rest of the movements, in the outer maritime ring. The outer maritime ring is used in this study as a surrogate for analysing the geographical extension of North Korean forelands. Traffic by inter-port link and by foreign port are calculated summing vessel capacities using slot capacities in Twenty-Foot Equivalent Units (TEUs) and commercial capacities in Deadweight Tons (DWTs)

[Insert figure 2 about here]

## 1.2 Methodology

Connectivity is defined as an “aggregate measure of the extent to which the nodes of a network are linked (directly or indirectly) to other nodes” [17]. Connectivity differs from connexity: the former measures the whole network, while the latter measures one element of the network.

Several indicators can be used to measure maritime connectivity and connexity using vessel movements (see table 1). Connectivity refers to the situation of North Korea in the global maritime system formed by the ships calling at its ports. It can be measured by the number of ports connected, or by the number of calls worldwide, through vessel movements. Connexity, on the other hand, measures traffic at individual ports or port groups realized by those vessels. Concentration is measured by the highest traffic share within the first maritime ring and by the Gini coefficient, as in previous studies of port concentration [18]. Our approach is original because it applies the Gini coefficient to external port connections rather than to a given port range or more classical, continental port system.

The aim of this paper is to find some correspondence between the evolutions of the two maritime rings. Hub dependence manifests as one link becomes concentrated within a larger transport chain; it is derived from the quality of different elements of maritime systems, including ports and shipping companies. Multi-scalar changes in the maritime system will more or less influence the degree of hub dependence. There is no fixed threshold from which hub dependence should be defined. Thus, we assess hub dependence by comparing the extension and concentration of North Korea’s first and outer maritime rings.

[Insert table 1 about here]

## **2. Evolution and distribution of North Korea's maritime linkages**

### **2.1 General trends**

Following the Korean War (1950-1953) and separation from then-Republic of Korea (hereafter referred to as South Korea), the North Korean economy officially adopted the ideology of self-sufficiency while sustaining predominant commercial relations with China and the USSR, which were bordering neighbours. While the steady growth of the North Korean economy through the 1970s can be explained by massive investments in heavy industries and construction, it has been supported since by China and Russia. Such a system started to falter in the mid-1980s with the collapse of the USSR. Paradoxically, it is because of trade dependence that North Korea has become isolated and unable to modernize its transport and economic system. Without oil or capital, most activities, including agriculture, mining, and transport, have ceased since then [19]. In addition, the lack of investment in light industries and consumer goods, due to the priority given to heavy and defence industries, have prevented the development of a competitive advantage in the world economy [20]. The mid-1990s accentuated this dramatic situation after the death of former president Kim Il-Sung, who was replaced with Kim Jeong-Il (1994-1996). Massive floods due to deforestation resulted in spreading famines, and the first nuclear crisis was condemned by the US with the Wassenaar Agreement (1996), putting a commercial embargo on North Korea.

It is only since 2000 that signs of change have appeared, notably with the historical inter-Korean summit, economic reforms, foreign investments, and cooperation projects such as the Gaeseong Industrial Park [21]. The Mount Geumgang International Tourism-Free Zone has attracted many South Korean tourists. These expanding projects financed by South Korea have much better results than earlier projects, such as the Rajin-Seonbong Free-Trade Zone, the Korean Peninsula Energy Development Organization (KEDO), and the Sinuiju Special Administrative Region, which have been limited due to politics and mismanagement [22].

Although broad evolutions of the North Korean economy are well addressed in various papers and official reports, there is a huge lack of information on the transport sector. Recent studies have estimated the domestic modal split [23] and the relative importance of sea transport in total trade [24]. Maritime trade in North Korea oscillated between 10% and 20% in the past two decades; this share has been quite stable except from a slight increase during the peak period of humanitarian aid in the late 1990s.

#### 2.1.1 Port development in North Korea

Due to preferential landward transport and border trade with China and Russia, North Korea has neglected the development of maritime transport and of its ports, although it announced a development plan in 1961 to develop this sector. As a result, the ports and commercial fleet – mostly composed of small ships - have aged and deteriorated over time. Since the 1970s, only oil piers and warehouses have been built in the ports; there is a drastic lack of general cargo and container-related equipments. Excessive port entry fees and special permits required from foreign ships have resulted in high shipping costs to and from the country as well as prolonged berthing time. Also, the limited size of the North Korean market and the external pressures stemming from trade embargos make maritime transport imbalanced, with approximately half of all containers returning empty.

However, some improvements at the Nampo and Rajin ports are underway through Chinese support [25], but many other South Korea-related projects concerning the Nampo, Wonsan, and Heungnam ports have failed due to politics. Per the inter-Korean summit of October 2007, the South Korean government plans to develop the Haeju port as a means to foster export-led growth from the nearby Gaeseong Industrial Complex.

#### 2.1.2 International trade and maritime transport



Traffic evolution by main commodities is the first step in the analysis of the maritime dynamics (see figure 3). General cargo occupies the largest capacity, because maritime transport in North Korea is used as a complement to land transport, which is mostly used for raw materials and bulky products [26].

[Insert figure 3 about here]

The two categories on which North Korea is the most dependent, general cargo and liquid bulk have declined more rapidly. The decline of liquid bulk traffic since 1987 is due to worsening relations with traditional Socialist partners that once provided oil in exchange of other goods. North Korea has not been able to purchase oil on the world market due to the lack of foreign currencies. The peak of liquid bulk traffic between 1998 and 2002 clearly indicates the effect of humanitarian aids, which is also the case for solid bulks. Bulk traffic has been more stable for two reasons. First, North Korea possesses enormous amounts of natural resources, such as sands, mine products, and ferrous and non-ferrous minerals that can be exported. Moreover, since the North Korean economic system is dominated by agriculture and heavy industries, it has continued purchasing low-valued goods on the world market, although it is estimated that only 20% of existing factories are still in operation [27]. Finally, container and roll-on / roll-off ships are of minor concern, due to the lack of container handling facilities in this country and to the limited trade, consumption, and production of finished and semi-finished products.

A general look at the relative evolution of trade and shipping verifies the importance of sea transport for international trade. Figure 4 presents relative values based on 1985 figures for total international trade (US\$) and total vessel capacity passing through North Korean ports (DWT).

[Insert figure 4 about here]

Shipping activity has constantly declined. There are important differences with the evolution of international trade. First, the gap between trade evolution and shipping evolution indicates that trade has become increasingly land-based, due to the retreat of North Korea from the global economy and the trade embargo. Between 1987 and 1990, there is a sudden fall of oil shipments for which sea transport was the dominant mode, at a time of loosening ties with the Soviet Union and China. Between 2002 and 2006, most trade is mostly based on land transport as 80% of North Korean exports pass through the border city of Sinuiju. Conversely, the parallel growth of trade and shipping from 1998 to 2001 illustrates the peak of humanitarian aid imports. The short but noticeable peak of maritime activity between 2004 and 2005 can be attributed to lower shipping costs between North Korea and South Korea, following an inter-Korean maritime agreement destined to liberalize the circulation of Korean ships.

## **2.2 North Korea's maritime connections**

### **2.2.1 Global contraction of maritime forelands**

The analysis of vessel movements provides a detailed snapshot of North Korea's global maritime connectivity. Three periods are retained to obtain a clearer view of the different situations, since they are relevant for the study: pre-USSR collapse (1985-1991), isolation and crisis (1992-1998), aid, economic reforms, foreign investments, and inter-Korean cooperation (1999-2006).

During the first period, North Korea's foreland extension is relatively wide, reflecting its belonging to the Socialist block through the Europe-Asia link (figure 5a). Ports having

high connexity are pivotal nodes connecting the different sub-regions, such as Istanbul for the Black Sea, Gibraltar, Port Said, Suez, and Aden for Europe, Singapore and Hong Kong for connecting Europe with Asia, and Panama for accessing Latin America, of which Cuba. Geographically closer countries such as India, Thailand, Bangladesh, and Indonesia also concentrated a strong proportion of connexity during this period. The period from 1992 to 1998 marked the end of North Korea's long distance trades, which were dominated by relations within the Socialist block (figure 5b). Ports that sustained relations with North Korea during this period concentrated within East Asia (e.g. Japan, China, Russia) and South Asia (e.g. India, Indonesia, Philippines). Almost all connections outside of East Asia have disappeared. From 1999 to 2006, there has been a huge increase of vessel movements (figure 5c). Although most connections still concentrate within Northeast Asia, some have spread outside Asia, as reflected in the high connexity of some strategic European passages such as Gibraltar, Tarifa, Cape Finisterre, and the Dover Strait.

[Insert figures 5a, 5b, 5c about here]

Based on the data, calculating connexity shares by main regional area allows confirming some main trends from 1985 to 2006. For instance, Asia as a whole increased from 63% to 93%, which indicates the global contraction of North Korea's maritime connectivity. Within Asia, Northeast Asia increased from 38% to 71%, while Middle East decreased from 5.2% to 0.6%. This confirms the contraction of foreland towards proximate neighbours, and the inability purchasing oil products on the world market. Europe decreased from 18.8% to 2.9%, notably due to the disappearance of relations with the Black Sea, a key trading area of the USSR (from 6.8% to 0.2%). Important gateways to Soviet hinterlands, which were once well connected, are not connected anymore after 1991, such as Odessa,

Yuzhnyy, Illichivsk, Nikolayev, Rostock, Wismar, Szczecin-Swinoujscie, Gdansk, Gdynia, Constanta, Novorossiysk, Tuapse, Bourgas, and Varna. Decrease is also dramatic for other brother countries situated in Latin America (from 2.8% to 0.1%) and Africa (from 9.1% to 1.2%), such as Angola, Cuba, Nicaragua, Libya, and Algeria [28]. It also indicates the loosening of long-distance connections with the two strategic canals (Suez, Panama).

### 2.2.2 Regional concentration of traffic

The concentration of traffic and vessel movements regionally is one important element leading to hub dependence. We hypothesize that the loss of long-distance direct calls explains the regional lock-in of vessel movements within Northeast Asia. To shed light on this phenomenon, we calculated the share of the first maritime ring (direct links) in total connectivity (total links). The higher the share of the first maritime ring, the more likely is the concentration of traffic within neighbouring transit ports. This concentration conditions the emergence of hub dependence. In figure 6, the two indicators are relatively proximate during the first period (1985-1991), but there is a growing gap between them in the second period (1992-1998). Long distance calls and services have been gradually replaced by short-sea movements, and traffic has become more geographically dispersed. The dramatic decrease of trade flows prevents from connecting important transit ports such as Singapore or Hong Kong. Instead, traffic is distributed more evenly through small shipments among the closest ports. The third period shows an inversion with higher traffic concentration and increased importance of the outer maritime ring. Traffic in the latter has been reactivated due to humanitarian aids (1999-2001) and to real trade at a time of economic reforms and foreign investments, notably with the European Union (2002-2006) [29]. This means that fewer ports tend to ensure North Korea's connection with the outer maritime ring. In the end, results show

that traffic concentration is more likely to occur in a period of foreland extension than in a period of foreland contraction.

[Insert figure 6 about here]

The application of the Gini coefficient provides a useful verification of such phenomenon (figure 7) [30]. Two trends are highlighted: decrease and increase. Although port concentration has existed before 1991, the crisis provoked dispersion in the first maritime ring until concentration reappeared gradually and at a higher level. Remote pivotal transit ports situated in areas outside of Northeast Asia were disconnected from North Korea and were replaced by closer transit hubs with higher concentration. Thus, there was a shift from remote hubs to neighbouring hubs. This shockwave altering the spatial pattern of trade relations and vessel circulations constitutes strong evidence of hub dependence. In the recent period, only a few direct connections concentrate most of North Korea's maritime traffic. Regional proximity is indeed a main component of hub dependence.

[Insert figure 7 about here]

Such trends indicate the close relation between the dimension of forelands' geographical coverage and traffic concentration. This results from local constraints such as derelict port infrastructures, trade embargo, war risk, and political tension with the outside world. Despite positive economical factors in the recent period, the spatial distribution of maritime connections is still constrained by technical and political factors. For instance, long-distance direct calls and large vessels may not ship at North Korean ports despite international trade. Only feeder vessels are likely to access North Korean ports, a very contrasting picture

with the one pre-1991. Such evidence may be sufficient assessing hub dependence which is not only a matter of maritime traffic but also has strong political implications. However, a closer look at the ports upon which North Korea has become hub dependent is necessary.

### **3. South Korea as North Korea's main hub**

#### **3.1 Centrality and intermediacy of South Korean ports**

When zooming on the distribution of North Korea-related container traffics measured in slot capacities within Northeast Asia, there is a clear trend towards concentration at South Korean ports in the recent period (see figure 8). The dominance of Incheon may be explained by its more favourable location connecting the Nampo-Pyongyang corridor that concentrates most of North Korea's population, factories, and foreign investments [31]. Thus, Incheon has replaced Dalian as the leading hub in the Yellow Sea, while Busan has overthrown Japanese ports for transshipment between Northeast Asia and the rest of the world [32]. This confirms the general properties of transportation hubs [33] [34], since South Korean ports combine a good centrality and good intermediacy.

Several explanations can be given to the rise of South Korea as the leading hub. First, 90% of the continuously growing inter-Korean trade occurs through sea transport due to the blockage at the demilitarized zone (DMZ) between the two Koreas. In addition, the successful economic cooperation projects following the inter-Korean summit required important shipments of raw materials and manufactured goods to build and start, notably, the Gaeseong Industrial Park. In order to facilitate sea transport, institutional arrangements such as the inter-Korean maritime agreement (2004) focused on opening new sea routes and fostering inter-Korean port cooperation, resulting in the agreement between Incheon and Nampo (2005) for regular ferry and container services. One should not forget the advantageous situation of South Korea as a pivotal hub allowing optimizing the servicing of both east and west coasts of

the peninsula, in a context of maritime network reorganization of interested shipping lines in Northeast Asia [35]. This position is backed by the recent policy of South Korea to become Northeast Asia's logistics hub, based upon the new role of Incheon's Pentaport within the Yellow Sea, and the double hub of Busan and Gwangyang aiming at reducing competition from rapidly growing Chinese ports [36]. As a result, we have calculated that about 90% of all containers going to (and coming from) North Korean ports have passed through South Korean ports in recent years.

This analysis shows the close connection between spatial, economical and political factors in the emergence of South Korea as North Korea's hub. Since this phenomenon is relatively new, it needs further study by looking at the hub dependence degrees of the different North Korean ports.

[Insert figure 8 about here]

### **3.2 The variability of hub dependence**

Hub dependence also varies from one port to another based on local trade routes and the resilience of maritime systems to geopolitical change [37]. For the three periods, we calculate the share of main direct external connections for every North Korean port, inbound and outbound (see table 2).

Traffic concentration at South Korean ports has become dominant for a few ports, of which Haeju (93% inbound and 96% outbound), Heungnam (50% inbound and 60% outbound), Cheongjin (30% outbound), and Songjin (52% outbound). For Haeju, the high hub dependence may be explained by recent agreement on sand extraction and barging at the mouth of the Han River. In the case of Heungnam and Cheongjin, aid shipments are a large component of the flows, since the two ports are isolated from the rest of the country due to the

dereliction of the transport system [38]. For other North Korean ports, the hub dependence on South Korean ports remains lower, but it increased rapidly.

Some North Korean ports tend to sustain long-distance direct connections reaching outside Northeast Asia. Such linkages still dominate in the recent period for Cheongjin (37% inbound) and Songjin (50% inbound), showing the importance of international trade over hub dependence. These ports usually locate nearby large cities (Cheongjin), large hinterlands and industrial complexes (Nampo-Pyongyang), or are situated close to cooperation projects (e.g. KEDO project for Songjin; Rajin-Seonbong Free-Trade Zone). Therefore, ports which maintain some economic activity are more likely to prevent from hub dependence upon South Korea.

Finally, we observe a regional specialization of maritime linkages. For instance, Eastern ports keep important relations with Russia (e.g. Rajin, 57% outbound) and Japan (Wonsan, 48% inbound and 56% outbound due to the ferry link with Niigata). Even for some ports, Japanese traffics are still dominant, as for Cheongjin (38% outbound), Wonsan, but also Nampo (30% inbound and 34% outbound) that is located on the West coast. This occurs despite the declining trade between North Korea and Japan and the banning of North Korean ships from Japanese ports.

[Insert table 2 about here]

### **3.3 Towards a model of hub dependence in port systems?**

Based on the North Korean experience, a three-stage evolutionary model of hub dependence is proposed in figure 9. The first stage represents a trading port (or country) that connects to other remote trading ports through mostly direct calls. It has a dominant position regionally (load centre) since it does not depend on neighbouring transit ports and acts as a



hub towards other trading ports. The second stage shows the concentration of direct calls at the first maritime ring, before and after accessing the trading port. The latter becomes a secondary port although it manages to sustain its position in the port system by welcoming as many direct calls as the competing hub ports. In the last stage, the secondary port becomes a peripheral port because it connects to the rest of the world through one main hub, which receives the majority of direct calls of larger vessels. While this peripheral port sustains some links with other neighbouring ports, it is not able to handle its own trade flows: those are split among smaller vessels accessing the main hub through feeder services. The model cannot encompass the wide diversity of local situations and problems that contribute to hub dependence, because they greatly vary in nature and scope (e.g. geographical location, lack of space, handling costs, congestion, etc.). Also, the three stages may be in reality slightly overlapped rather than strictly delimited. As in the North Korean case, hub dependence occurs while some ports maintain long-distance connections.

In cases other than North Korea, such a model may also help understanding how peripheral ports become load centres. Shenzhen ports gradually relieved their hub dependence from Hong Kong over time [39]. They have become load centres welcoming direct calls from most of the world's main ocean carriers, thus bypassing Hong Kong's predominance as a hub port. In the case of Japanese ports, the national port policy seems intentionally avoid the development of hub functions within Japan, since this costly, space consuming, and low-benefit function is already developed in neighbouring countries [40]. Despite the variety of regional port systems, this model may help to reveal interesting discrepancies among trading ports according to their level of hub dependence.

[Insert figure 9 about here]

## Conclusion

This paper has demonstrated the economic factors and spatial mechanisms giving birth to hub dependence in the case of a constrained economy. An original methodology based on vessel movements provides a geographical pattern that improves understanding of shipping line behaviour on various scales. The shift from long-distance to short-sea shipping is measured through the evolution of direct and indirect maritime relations with foreign ports. Hub dependence is a combination of trade growth and local constraints. In the case of North Korea, hub dependence is the consequence of a period of economic decline accentuated by political tensions, which were partly overcome by recent economic reforms and increased foreign investments. However, hub dependence may greatly vary within a single country, as it demonstrated by Russia, Japan, China, and South Korea. Notably, hinterland size and regional proximity are strong factors that reduce the hub dependence on South Korean ports.

In terms of policy outcomes, the results need further discussion. For instance, it may appear rather surprising that South Korea has become North Korea's maritime hub. Discussions with South Korean officials and economic players [41] involved in North Korean development indicate that traffic concentration at South Korean ports is probably a self-organizing process resulting from port selection by the shipping lines and this was not planned either by South Korean or North Korean decision-makers. Although China is North Korea's main trade partner and exerts a growing influence on North Korea's development, Chinese ports are not well located for developing hub-feeder networks with North Korea. Therefore, hub dependence is based on economic rather than political factors because it reflects the consequence of local constraints on port selection. Overlapping behaviours of multiple shipping companies reveal which port is best located in terms of centrality and intermediacy. Such methodology may be applied elsewhere to evaluate the impact of port

planning on foreland extension. Notably, countries and ports that are willing to measure their hub dependence may benefit from such research agenda.

Whether North Korea's hub dependence on South Korean ports is related to South Korea's strategy of becoming Northeast Asia's logistics hub still needs to be demonstrated, but still there a striking coincidence between the two phenomena. Is hub dependence a temporary phenomenon that is likely to disappear with port modernization and market development? In fact, North Korea's hub dependence may either increase or decrease in the future depending on the worsening or the betterment of the country's economy and transport system. More economic growth and the development of export-based industries will face the limitations of road, rail, and port infrastructures internally, leading to increased hub dependence externally. However, improving port facilities may not be sufficient to solve wider issues of which trade embargo and cumbersome regulations in North Korean ports. Without a peace treaty with South Korea negotiated with the US, progress will be slow, irregular, and fastidious.

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**Table 1: Selected indicators**

<b>Type of indicator</b>	<b>Calculation method</b>	<b>Geographical level</b>
Concentration	Maximum percentage of traffics among ports directly connected to North Korean ports through vessel movements	First maritime ring
	Gini coefficient applied to foreign ports directly connected to North Korean ports through vessel movements	First maritime ring
Connectivity	Number of connections (e.g. ports, calls) realized by vessels which have included North Korean ports in their yearly movements	First maritime ring, Maritime region, World
Connexity	Number of vessel calls by port directly or indirectly connected to North Korean ports through the yearly movements of vessels	Port

Source: author

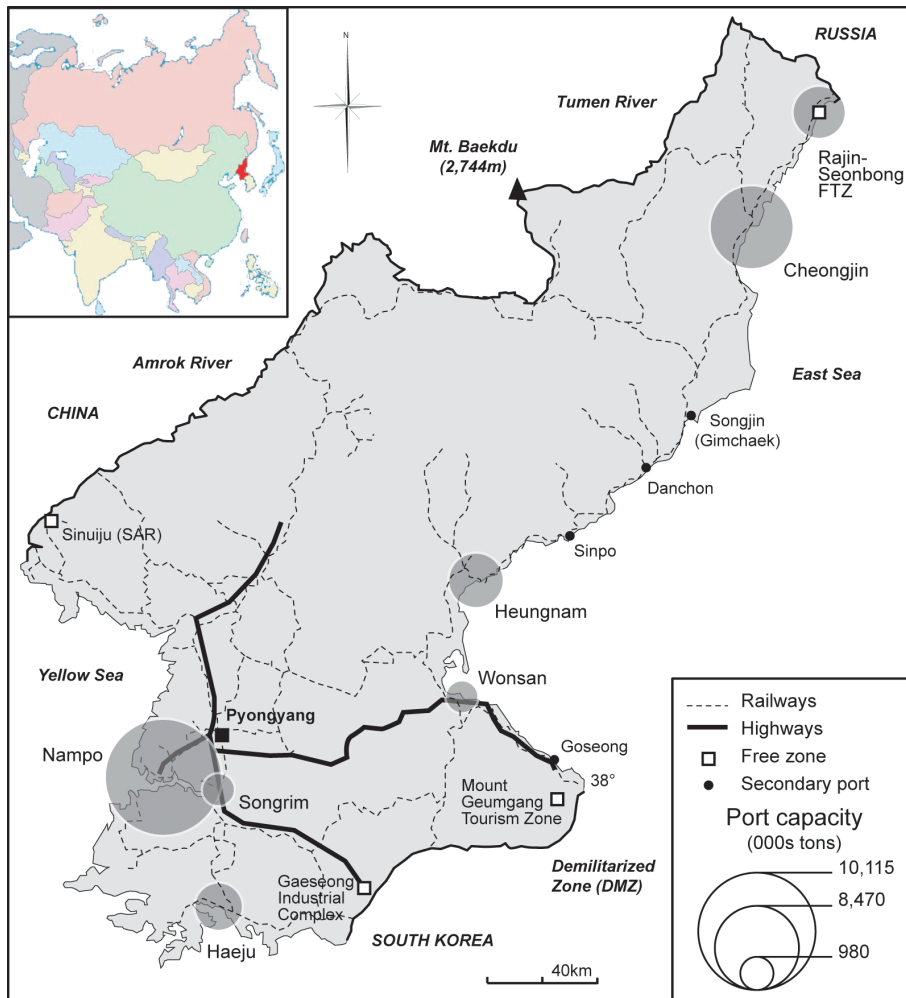
**Table 2: Distribution of direct maritime connections of North Korean ports by country and period, 1985-2006 (Unit: % DWT)**

Port	Country	Inbound			Outbound		
		1985-1991	1992-1998	1999-2006	1985-1991	1992-1998	1999-2006
Cheongjin	Japan	50.4	44.9	25.8	59.4	54.6	38.1
	China	14.1	21.0	7.5	16.3	10.6	5.0
	South Korea	0.8	7.7	27.2	1.0	19.7	29.8
	Russia	0.3	2.0	2.5	0.0	7.1	7.8
	Other	34.5	24.4	36.9	23.3	8.0	19.3
Haeju	Japan	18.7	49.2	2.7	29.6	77.7	3.7
	China	50.4	21.2	2.2	30.3	17.2	0.2
	South Korea	2.0	15.2	92.7	2.1	0.8	96.1
	Russia	1.8	4.3	0.0	0.0	0.0	0.0
	Other	27.1	10.2	2.4	38.0	4.3	0.0
Heungnam	Japan	33.2	33.0	11.2	46.3	41.1	13.9
	China	17.5	18.3	6.4	10.5	10.9	8.3
	South Korea	2.9	7.8	55.5	1.6	19.9	60.0
	Russia	1.2	3.1	3.7	0.5	1.0	3.3
	Other	45.2	37.8	23.2	41.1	27.1	14.5
Nampo	Japan	37.2	39.1	29.5	43.9	51.3	33.8
	China	28.4	27.6	17.4	28.6	26.0	19.9
	South Korea	3.4	7.5	24.8	4.4	7.2	30.3
	Russia	0.2	1.2	2.2	0.2	0.6	2.6
	Other	30.8	24.6	26.1	22.9	14.9	13.4
Rajin	Japan	54.8	40.4	43.1	61.8	69.3	32.8
	China	11.4	13.3	2.3	32.8	7.7	1.5
	South Korea	2.3	6.5	4.8	0.0	1.2	6.1
	Russia	17.7	17.3	37.1	2.2	6.2	57.2
	Other	13.8	22.5	12.7	3.2	15.6	2.4
Songjin	Japan	11.1	50.2	15.0	11.1	50.2	28.4
	China	0.0	8.0	0.0	41.0	0.0	3.3
	South Korea	0.0	0.0	26.9	0.0	8.0	52.3
	Russia	0.0	7.7	7.8	0.0	7.7	9.1
	Other	88.9	34.1	50.3	47.9	34.1	6.9
Wonsan	Japan	48.7	61.2	48.2	61.0	66.6	55.6
	China	2.0	16.4	2.3	1.9	3.8	3.9
	South Korea	36.5	6.2	23.7	26.6	9.2	23.7
	Russia	0.0	5.5	10.6	0.1	6.4	15.3
	Other	12.8	10.7	15.2	10.4	14.0	1.5



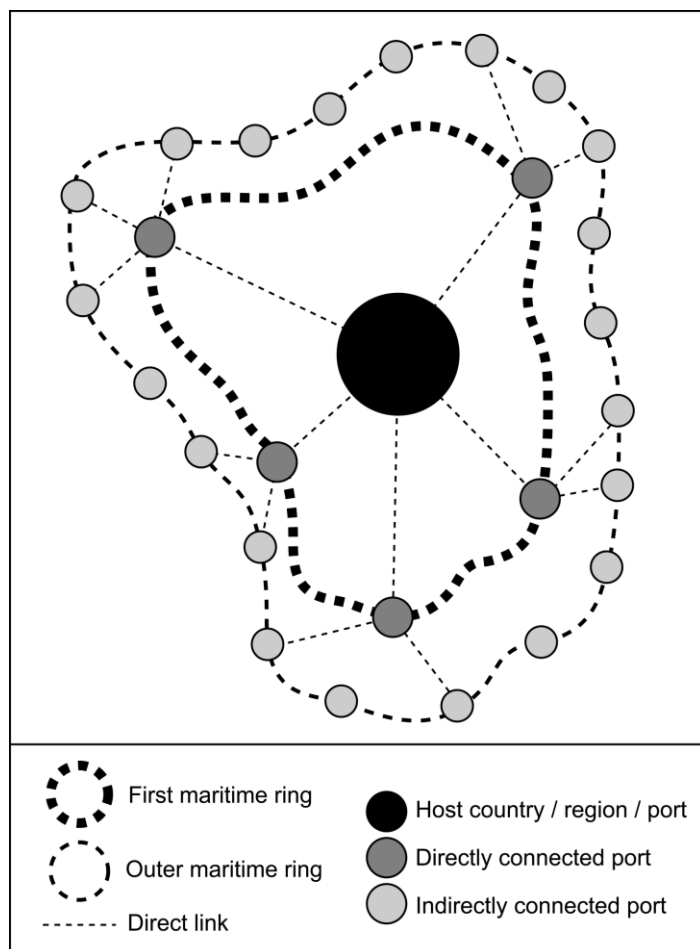


**Figure 1: The North Korean transport system**



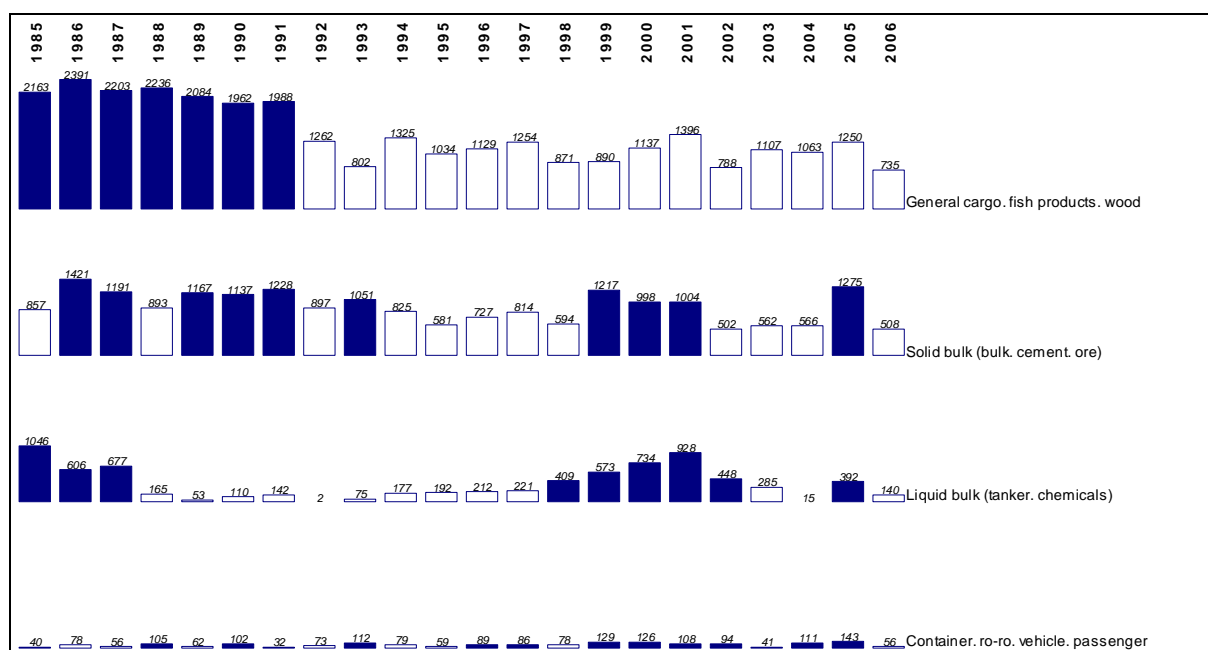
Source: author, compiled from various sources

**Figure 2: A geographical framework for analyzing hub dependence**



Source: author

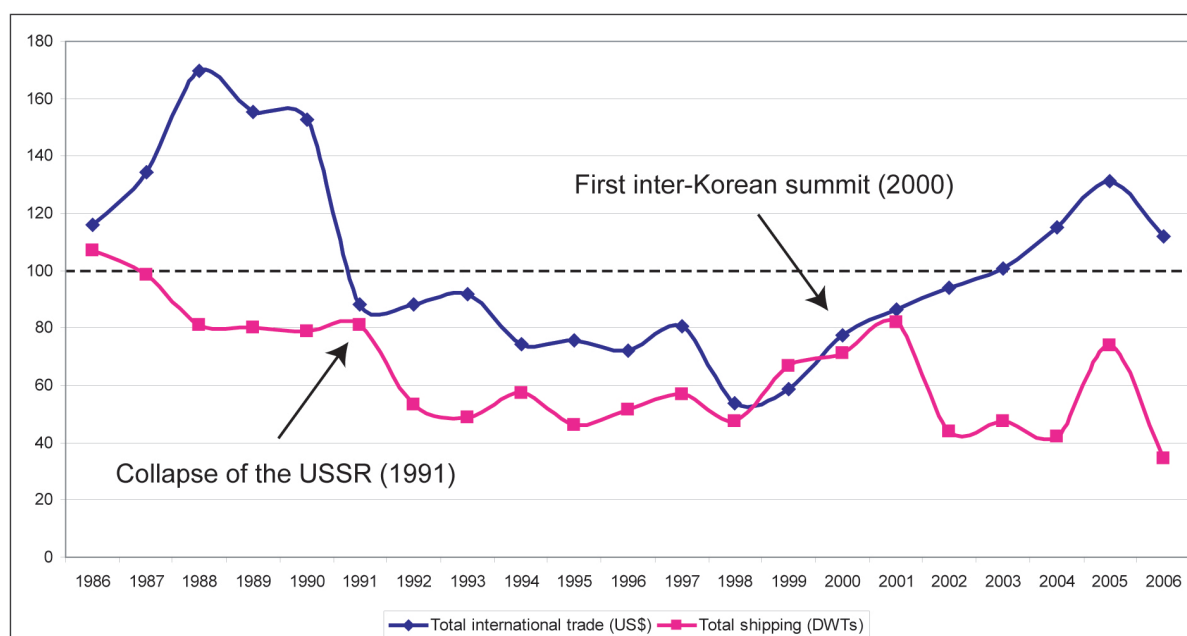
**Figure 3: Traffic evolution at North Korean ports by main commodity, 1985-2006 (Unit: 000s DWT)**



Sources: author, calculated from Lloyd's Marine Intelligence Unit (LMIU)

*N.B. Bold colour indicates values higher than the row's average*

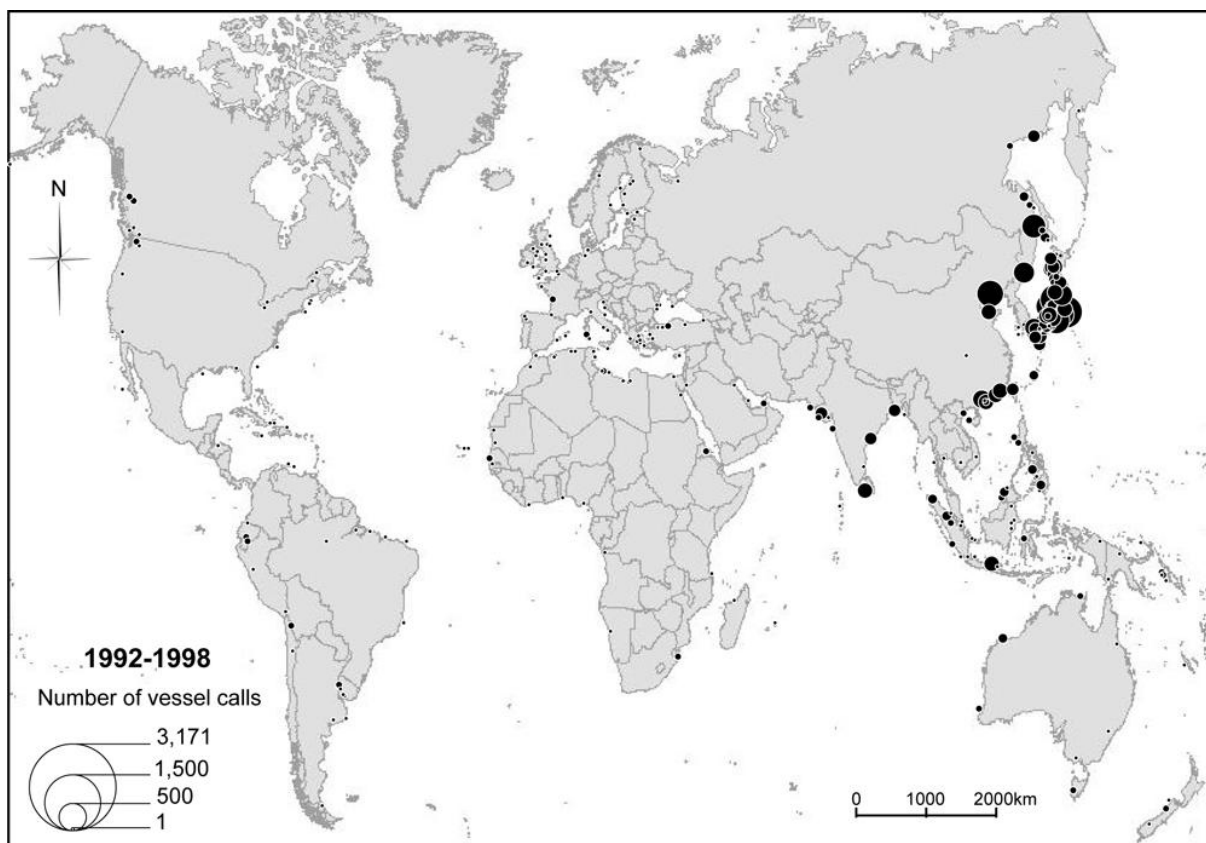
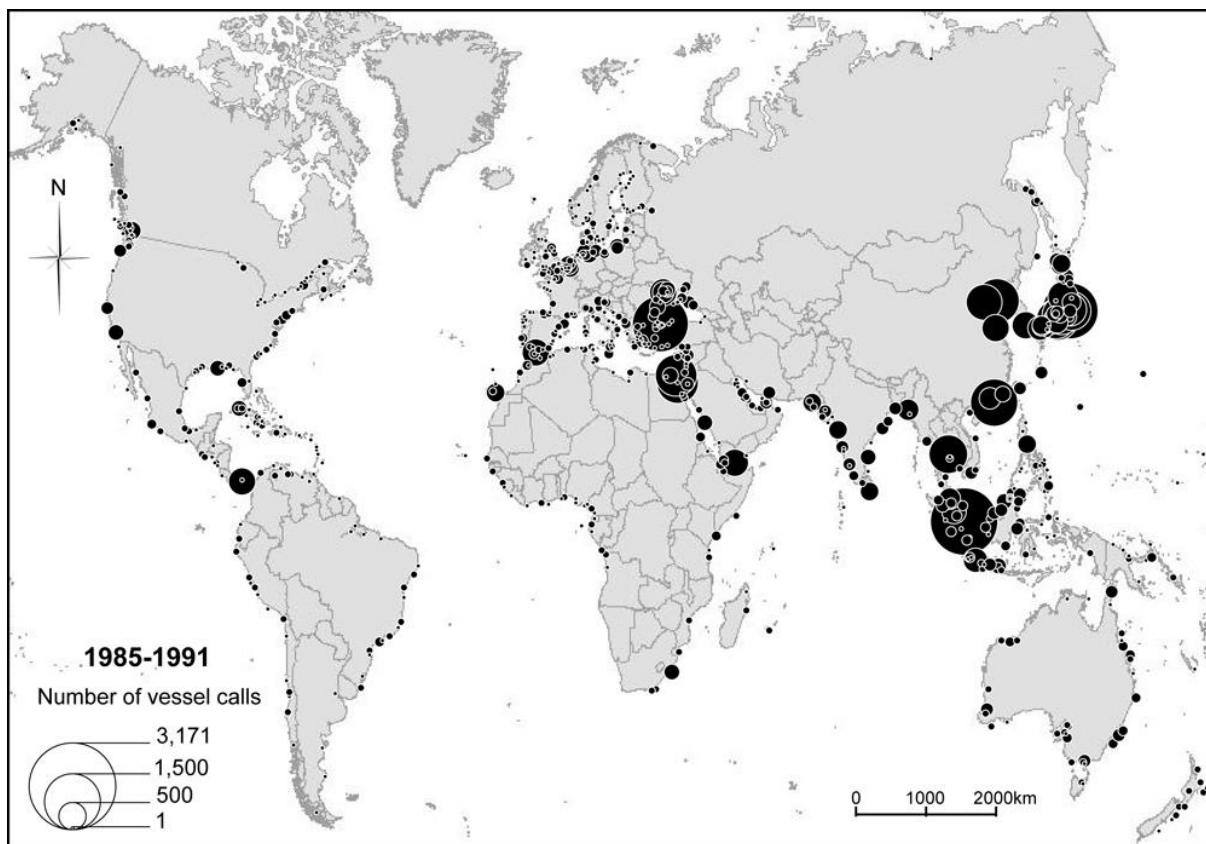
**Figure 4: Evolution of North Korean international trade and shipping, 1985-2006 (Base 1985=100)**

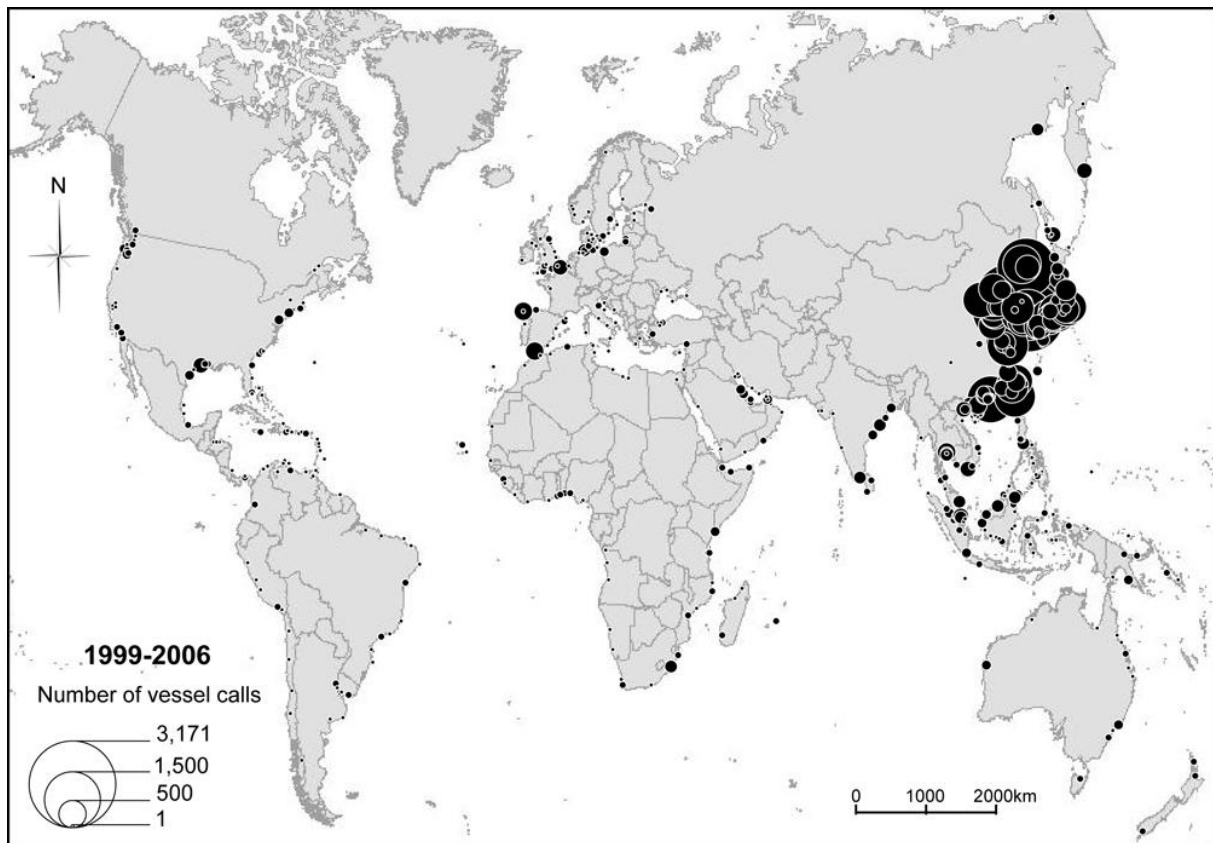


Sources: author, calculated from Korea Trade and Investment Promotion Agency (KOTRA) and Lloyd's Marine Intelligence Unit (LMIU)

*N.B. Total trade in 2006 comprises only trade with China, Japan, South Korea, Russia and Germany*

Figures 5a, 5b, 5c: Distribution of vessel movements connecting North Korean ports by port and period,  
1985-2006 (Unit: Number of calls)

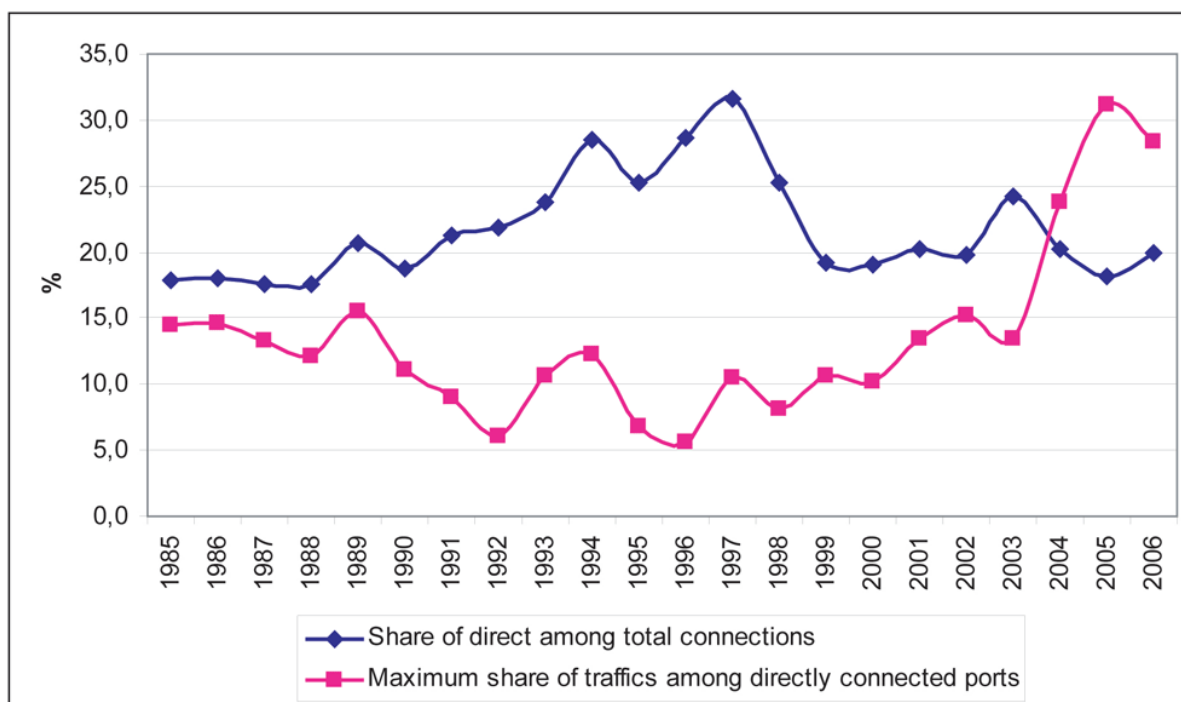




Source: author, calculated from Lloyd's Marine Intelligence Unit

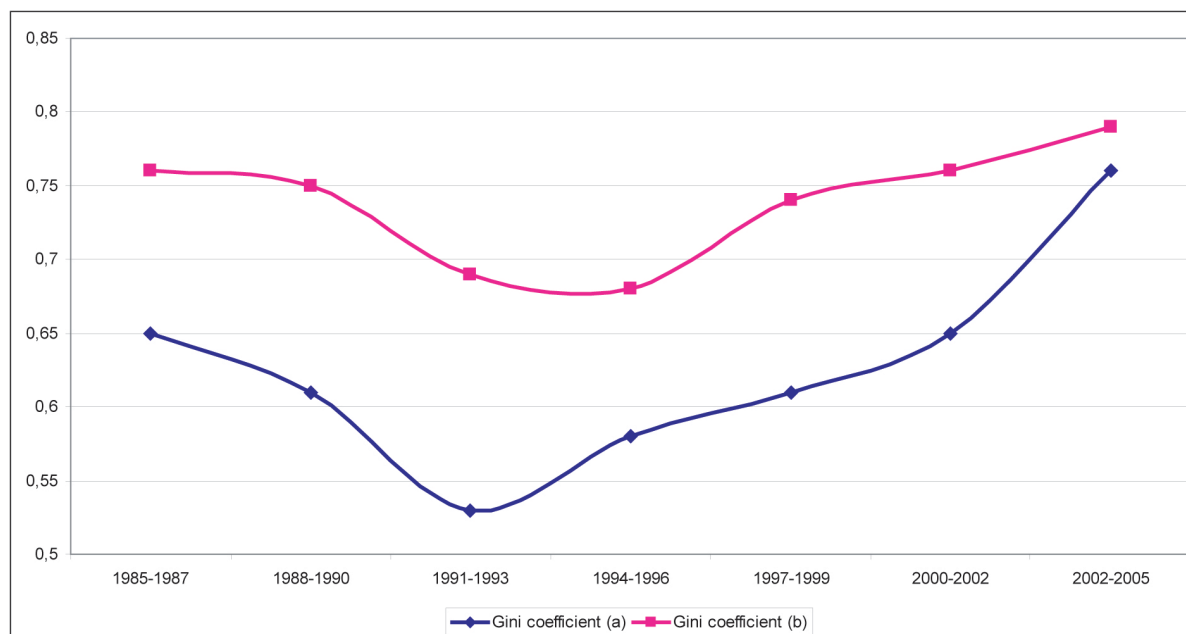
*N.B. Each map retains only the ports which have realized at least one third of their total calls during the period*

**Figure 6: Relative importance and traffic concentration of North Korea's first maritime ring, 1985-2006**



Source: author, calculated from Lloyd's Marine Intelligence Unit

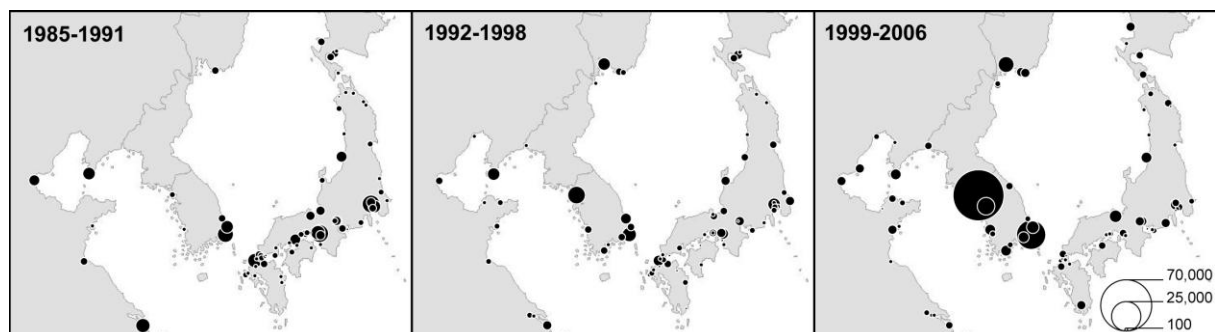
**Figure 7: Gini coefficient applied to North Korea's first maritime ring, 1985-2005**



Source: author, calculated from Lloyd's Marine Intelligence Unit

*N.B. (a) same 78 directly connected ports (b) all directly connected ports*

**Figure 8: Direct connections of North Korean ports within Northeast Asia by port and period (Unit: TEUs)**



Source: author, calculated from Lloyd's Marine Intelligence Unit

*N.B. Container traffics correspond to the sum of slot capacities in TEUs*

**Figure 9: A three-stage model of hub dependence**

Degree of hub dependence	Low	Medium	High
Type of trade port	Load center	Secondary port	Peripheral port
Level of maritime connectedness	Global	Regional	Local
Geographical setting			

Source: author